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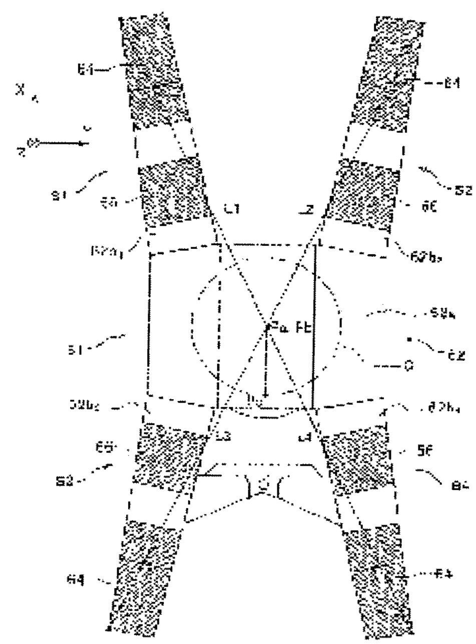
(54) LEG TYPE MOBILE ROBOT

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a leg type mobile robot provided with foot parts, capable of absorbing shock at the time of landing with simple structure and reduced in weight.
SOLUTION: The foot parts 17 of the robot are provided with plate spring parts S1, S2, S3 and S4. The plate spring parts S1, S2, S3 and S4 are respectively provided with spring parts 62b1, 62b2, 62b3 and 62b4 to be plate springs, a first intermediate member having a damping function, and a first sole member 64 having a non-slip function, and support self weight of the robot while bending when grounding on a floor surface.



CLAIMS

[Claim(s)]
[Claim 1]
He is a leg formula mobile robot having an upper body, the leg connected with said upper body via the first joint, and a foot connected with an end of said leg via the second joint,
Said foot is provided with a flat portion of a leg which has a grounding region grounded to a floor line in a lower end part,
A leg formula mobile robot, wherein said flat portion of a leg is provided with a flat spring part which supports prudence bending at the time of grounding.
[Claim 2]
The leg formula mobile robot according to claim 1, wherein said flat portion of a leg is provided with said two or more grounding regions.
[Claim 3]
The leg formula mobile robot according to claim 2, wherein said two or more grounding regions divide and are arranged forward and backward to said second joint.
[Claim 4]
The leg formula mobile robot according to any one of claims 1 to 3, wherein it has curved toward a top as at least one of said the grounding regions separates from said second joint.
[Claim 5]
The leg formula mobile robot according to any one of claims 1 to 4, wherein said flat portion of a leg is provided with the first pair-of-shoes bottom material which produces frictional resistance between said floor lines at the time of grounding as said grounding region.
[Claim 6]
The leg formula mobile robot according to claim 5 having the first pars intermedia material which attenuates vibration of said flat spring part at the time of grounding of said first pair-of-shoes bottom material between said flat spring part and said first pair-of-shoes bottom material.
[Claim 7]
The leg formula mobile robot according to claim 6, wherein said first pars intermedia material permits displacement of the direction of a floor line over said flat spring part of said first pair-of-shoes bottom material at the time of grounding of said first pair-of-shoes bottom material.
[Claim 8]
The leg formula mobile robot according to any one of claims 5 to 7, wherein said flat portion of a leg is provided with the second pair-of-shoes bottom material which produces frictional resistance between said floor lines at the time of grounding up rather than said first pair-of-shoes bottom material.
[Claim 9]
The leg formula mobile robot according to claim 8 having the second pars intermedia material which attenuates vibration of said flat spring part at the time of grounding of said second pair-of-shoes bottom material between said flat spring part and said second pair-of-shoes bottom material.
[Claim 10]
The leg formula mobile robot according to claim 9, wherein said second pars intermedia material

permits displacement of the direction of a floor line over said flat spring part of said second pair-of-shoes bottom material at the time of grounding of said second pair-of-shoes bottom material.

[Claim 11]
The leg formula mobile robot comprising according to any one of claims 1 to 10:
Said flat portion of a leg is a base.
Said two or more flat spring parts which are caudad extended from said base and by which said grounding region was formed in the bottom side.

[Claim 12]
The leg formula mobile robot according to claim 11, wherein it had said four flat spring parts, and said two flat spring parts of them were ahead extended from said base, and said two remaining flat spring parts are extended from said base to back and said four flat spring parts and said base are making the shape of an abbreviated H character.
[Claim 13]
The leg formula mobile robot according to any one of claims 1 to 12, wherein said flat spring part is formed from a combined member strengthened with textiles.
[Claim 14]
The leg formula mobile robot according to any one of claims 1 to 13, wherein said flat spring part consists of several layers from which an elastic modulus differs.
[Claim 15]
The leg formula mobile robot comprising according to any one of claims 1 to 13:
A flat spring in which said flat spring part was multilayered.
A viscous member interposed between said flat springs.

[Claim 16]
The leg formula mobile robot having an attenuating means which attenuates vibration of said flat spring part according to any one of claims 1 to 15.
[Claim 17]
The leg formula mobile robot according to any one of claims 1 to 16, wherein said flat spring part is provided with a connecting part with which those with two or more and said two flat spring parts are made to connect.
[Claim 18]
The leg formula mobile robot according to any one of claims 1 to 17, wherein said foot is provided with a floor-reaction-force detection means to detect floor reaction force which acts from said floor line via said flat portion of a leg.
[Claim 19]
The leg formula mobile robot according to claim 18, wherein said floor-reaction-force detection means is the floor-reaction-force detector by which unitization was carried out.
[Claim 20]
The leg formula mobile robot according to claim 19, wherein said flat portion of a leg is being fixed to said floor-reaction-force detector.
[Claim 21]
Said flat portion of a leg is provided with said two or more grounding regions,
The center of said second joint is offset to a position from which distance to an apogee of two or more of said grounding regions serves as the minimum by plane view,
The leg formula mobile robot according to claim 19 or 20, wherein the center of said floor-reaction-force detector is established so that distance to an apogee of two or more of said grounding regions may become close to a position used as the minimum by plane view rather than the center of said second joint.
[Claim 22]
Said flat portion of a leg is provided with said two or more grounding regions,
The leg formula mobile robot according to claim 19 or 20, wherein said floor-reaction-force detector is formed in a position from which distance to an apogee of two or more of said

grounding regions serves as the minimum by plane view.

[Claim 23]

The leg formula mobile robot according to claim 18, wherein said floor-reaction-force detection means is a distortion detection means to detect distortion of said flat spring part.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[Field of the Invention]
[0001]
This invention relates to a leg formula mobile robot.
[Background of the Invention]
[0002]
Art given in the patent documents 1 is known, for example as art about the foot structure of a leg formula mobile robot, especially a leg formula mobile robot. The foot of the leg formula walking robot of a statement is ** constituted by the patent documents 1 sequentially from a top with 6 axial force sensors (floor-reaction-force detector) which detect floor reaction force, the spring mechanism object provided with the rubber bush which has an impact-absorbing function, a vola frame, a vola plate, and a sole.
6 axial force sensors are connected to the vola frame via the spring mechanism object.
It has composition which can be reduced when a rubber bush transforms the shock added to 6 axial force sensors at the time of landing, especially the shock committed to an oblique direction.

[Patent documents 1] JP,2003-71776,A (the paragraphs 0040-0046, drawing 2)
[Description of the Invention]
[Problem(s) to be Solved by the Invention]
[0003]
However, it has the problem that the patent documents 1 have many part mark as for the leg formula walking robot of a statement, and structure is complicated.
And to raise the speed (a walk, a run) of movement is desired in the above mentioned leg formula walking robot. When a leg formula walking robot moves at high speed, a big inertia force arises in the leg. In order to make this inertia force small, as for the end side of the leg, a weight saving of the foot is desired.
As for the foot of a leg formula walking robot, since the impulse force by the floor reaction force added to a foot at the time of grounding also becomes large when a leg formula walking robot moves at high speed, it is desirable that it is the structure where this impulse force can be borne.
[0004]
Though it is originated in view of the above mentioned background and is a simple structure, this invention can absorb the shock at the time of landing, and makes it SUBJECT to provide the leg formula mobile robot having the foot by which the weight saving was carried out.
[Means for Solving the Problem]
[0005]
In order to solve said SUBJECT, the leg formula mobile robot of this invention according to claim 1, Are an upper body, the leg connected with said upper body via the first joint, and a foot connected with an end of said leg via the second joint the leg formula mobile robot which had, and said foot, It had a flat portion of a leg which has a grounding region grounded to a floor line in a lower end part, and said flat portion of a leg is provided with a flat spring part which

supports prudence, bending at the time of grounding.
[0006]
In this invention, "grounding regions" is a floor line and a field to ground at the time of movement of a leg formula mobile robot.
In this invention, "prudence" is prudence of a leg formula mobile robot. One or more flat spring parts carry out ["for which prudence is supported bending"] elastic deformation, and it means supporting prudence of a robot according to elastic force of one or more flat spring parts. [it]
In this invention, a "flat portion of a leg" is a substructure of a leg formula mobile robot's foot, and is a portion which receives reaction force from a floor line. In this invention, prudence is supported by a flat portion of a leg being provided with one or more flat spring parts, one or more flat spring parts bending at the time of grounding.
[0007]
The leg formula mobile robot according to claim 2 is the leg formula mobile robot according to claim 1, and said flat portion of a leg is provided with said two or more grounding regions.
[0008]
In this invention, "two or more grounding regions" is grounding regions divided into plurality, for example, two or more flat spring parts are provided, and it is obtained by forming a grounding region of every a piece in each flat spring part. It is also possible to form two or more grounding regions to a flat spring part of a piece.
Thus, by having two or more grounding regions, even if it is in a state in which a leg formula mobile robot stood it still, a flat portion of a leg becomes possible [supporting a leg formula mobile robot with sufficient balance].
[0009]
The leg formula mobile robot according to claim 3 is the leg formula mobile robot according to claim 2, and to said second joint, forward and backward, said two or more grounding regions divide, and are arranged.
[0010]
For example, in a dipodia mobile robot which imitated human being, it imitates in a walk of human being and control which lands from the backside (heel part) of a flat portion of a leg, and has been kicked by a front side (tiptoe part) is performed. For a leg formula mobile robot of claim 3, since a grounding region is arranged at front and the backside, this control is performed suitably. Since control which a leg formula mobile robot's load center moves [control] to a leg formula mobile robot's cross direction, and moves the load center to an ideal position at the time of a leg formula mobile robot's advancing movement is performed, A leg formula mobile robot of claim 3 straddles by a grounding region of order, and becomes controllable [which moves a leg formula mobile robot's load center to a cross direction].
[0011]
The leg formula mobile robot according to claim 4 is the leg formula mobile robot according to any one of claims 1 to 3, and it has curved toward a top as at least one of said the grounding regions separates from said second joint.
[0012]
Thus, also when grounding bottom shape of a grounding region after a flat portion of a leg has inclined to a floor line by considering it as shape which curves toward a top as it separates from the second joint, a grounding region can be secured suitably. A crawler bearing area can be enlarged and frictional force between floor lines can be secured.
[0013]
The leg formula mobile robot according to claim 5 is the leg formula mobile robot according to any one of claims 1 to 4, and said flat portion of a leg is provided with the first pair-of-shoes bottom material which produces frictional resistance between said floor lines at the time of grounding as said grounding region.
[0014]
By doing in this way, it becomes difficult to slide on a flat portion of a leg to a floor line, and it can prevent a slip. Power of a leg formula mobile robot's leg can be efficiently told to a floor line.

[0015]
The leg formula mobile robot according to claim 6 has the first pars intermedia material which is the leg formula mobile robot according to claim 5, and attenuates vibration of said flat spring part at the time of grounding of said first pair-of-shoes bottom material between said flat spring part and said first pair-of-shoes bottom material.
[0016]
By doing in this way, vibration of a flat spring part produced at the time of grounding of the first pair-of-shoes bottom material can be attenuated by the first pars intermedia material, and destabilization of a leg formula mobile robot's posture accompanying vibration of a flat spring part can be prevented.
[0017]
The leg formula mobile robot according to claim 7 is the leg formula mobile robot according to claim 6, and said first pars intermedia material permits displacement of the direction of a floor line over said flat spring part of said first pair-of-shoes bottom material at the time of grounding of said first pair-of-shoes bottom material.
[0018]
By doing in this way, a gap of a grounding position in the first pair-of-shoes bottom material accompanying bending of a flat spring part can be suppressed.
[0019]
The leg formula mobile robot according to claim 8 is the leg formula mobile robot according to any one of claims 5 to 7, and said flat portion of a leg is provided with the second pair-of-shoes bottom material which produces frictional resistance between said floor lines at the time of grounding up rather than said first pair-of-shoes bottom material.
[0020]
By doing in this way, when moving in a floor line with level differences, such as stairs, even if it is a case where portions other than the first pair-of-shoes bottom material provided in the usual grounding region ground, when the second pair-of-shoes bottom material grounds, a slip can be prevented. Power of a leg formula mobile robot's leg can be efficiently told to a floor line.
[0021]
The leg formula mobile robot according to claim 9 has the second pars intermedia material which is the leg formula mobile robot according to claim 8, and attenuates vibration of said flat spring part at the time of grounding of said second pair-of-shoes bottom material between said flat spring part and said second pair-of-shoes bottom material.
[0022]
By doing in this way, vibration of a flat spring part produced at the time of grounding of the second pair-of-shoes bottom material can be attenuated by the second pars intermedia material, and destabilization of a leg formula mobile robot's posture accompanying vibration of a flat spring part can be prevented.
[0023]
The leg formula mobile robot according to claim 10 is the leg formula mobile robot according to claim 9, and said second pars intermedia material permits displacement of the direction of a floor line over said flat spring part of said second pair-of-shoes bottom material at the time of grounding of said second pair-of-shoes bottom material.
[0024]
By doing in this way, a gap of a grounding position in the second pair-of-shoes bottom material accompanying bending of a flat spring part can be suppressed.
[0025]
The leg formula mobile robot according to claim 11 is the leg formula mobile robot according to any one of claims 1 to 10, and said flat portion of a leg is provided with a base and said two or more flat spring parts which are caudad extended from said base and by which a grounding region was formed in the lower end part side.
[0026]
A flat portion of a leg which has two or more flat spring parts by doing in this way can be obtained with a simple structure. Although a flat spring part and a base may be constituted by

different body, it is also possible to carry out integral moulding. By making especially a flat spring part and a base into integral moulding, reduction of further part mark and simplification of structure of a foot are attained.

[0027]

The leg formula mobile robot according to claim 12, Are the leg formula mobile robot according to claim 11, and it has said four flat spring parts, Said two flat spring parts of them were ahead extended from said base, and said two remaining flat spring parts are extended from said base to back, and said four flat spring parts and said base are making the shape of an abbreviated H character.

[0028]

As "the shape of an abbreviation H character here", a flat spring part of a couple provided in the front and back, respectively may be mutually parallel, and it means that it may be provided so that it may open a little toward a tip part.

[0029]

For example, in a dipodia mobile robot which imitated human being, it imitates in a walk of human being and control which lands from the backside (heel part) of a flat portion of a leg, and has been kicked by a front side (tiptoe part) is performed. For a leg formula mobile robot of claim 12, since a grounding region is arranged at front and the backside, this control is performed suitably. Since control which a leg formula mobile robot's load center moves [control] to a leg formula mobile robot's cross direction, and moves the load center to an ideal position at the time of a leg formula mobile robot's advancing movement is performed, A leg formula mobile robot of claim 12 straddles by a grounding region of order, and becomes controllable [which moves a leg formula mobile robot's load center to a cross direction]. When being provided so that a flat spring part of a couple may open a little toward a tip part, straddle is effective even if it is a case where a leg formula mobile robot inclined to right and left, and load shifts to a longitudinal direction.

[0030]

The leg formula mobile robot according to claim 13 is the leg formula mobile robot according to any one of claims 1 to 12, and said flat spring part is formed from a combined member strengthened with textiles.

[0031]

As an example of "a combined member strengthened with textiles" in this invention, fiber reinforced plastics (FRP:Fiber Reinforced Plastic) which strengthened a plastic with textiles for strengthening are mentioned. As textiles for strengthening, it is suitably usable in carbon fiber, glass fiber, organic textiles, a metal fiber, etc. Thus, a flat spring part's own weight saving becomes possible by forming a flat spring part from "a combined member strengthened with textiles."

[0032]

The leg formula mobile robot according to claim 14 is the leg formula mobile robot according to any one of claims 1 to 13, and said flat spring part consists of several layers from which an elastic modulus differs.

[0033]

By doing in this way, vibration of a flat spring part in the time of movement of a leg formula mobile robot, etc. can be attenuated, and stabilization of a leg formula mobile robot's posture is possible.

[0034]

The leg formula mobile robot according to claim 15 is the leg formula mobile robot according to any one of claims 1 to 13, and said flat spring part is ** constituted with a multilayered flat spring and a viscous member interposed between said flat springs.

[0035]

By doing in this way, vibration of a flat spring part in the time of movement of a leg formula mobile robot, etc. can be attenuated, and stabilization of a leg formula mobile robot's posture is possible.

[0036]

The leg formula mobile robot according to claim 16 has an attenuating means which is the leg

formula mobile robot according to any one of claims 1 to 15, and attenuates vibration of said flat spring part.

[0037]

By doing in this way, vibration of a flat spring part in the time of movement of a leg formula mobile robot, etc. can be attenuated, and stabilization of a leg formula mobile robot's posture is possible. The first pars intermedia material and second pars intermedia material are also an example of an attenuating means. In addition, a damper gear using fluid pressure, etc. can be made into an attenuating means, and can be applied. According to the damper gear etc., it becomes possible to also attenuate vibration of a flat spring part produced when a flat portion of a leg separates from a floor line.

[0038]

The leg formula mobile robot according to claim 17 is the leg formula mobile robot according to any one of claims 1 to 16, and said flat spring part is provided with a connecting part with which those with two or more and said two flat spring parts are made to connect.

[0039]

By doing in this way, it becomes possible to adjust the spring characteristics of a flat portion of a leg, especially rigidity. Integral moulding of this connecting part may be carried out to a flat spring part, and it may attach and fix a connecting member of a flat spring part and a different body at each flat spring part. Shape of this connecting part, a setting position, the number, etc. can be changed suitably.

[0040]

The leg formula mobile robot according to claim 18 is the leg formula mobile robot according to any one of claims 1 to 17, and said foot is provided with a floor-reaction-force detection means to detect floor reaction force which acts from said floor line via said flat portion of a leg.

[0041]

Floor reaction force inputted as a "floor-reaction-force detection means" via a flat portion of a leg in this invention, It is for detecting at least one side of a moment of advancing-side-by-side power of floor reaction force, and floor reaction force in detail, and it is good if detection of advancing-side-by-side power or a moment (for example, power Fz of shaft orientations vertical to a floor line) of at least 1 shaft orientations is possible.

Thus, by forming a floor-reaction-force detection means in a foot, it becomes detectable at a place nearer to a grounding region, and floor reaction force can be detected more correctly.

[0042]

The leg formula mobile robot according to claim 19 is the leg formula mobile robot according to claim 18, and said floor-reaction-force detection means is characterized by being the floor-reaction-force detector by which unitization was carried out.

[0043]

In this invention, "unitization" means composition of having incorporated parts in one case. That is, it is the floor-reaction-force detector which incorporated parts of a floor-reaction-force detection means in a case. Thus, an assembly of a foot becomes easy by using a floor-reaction-force detector by which unitization was carried out.

[0044]

The leg formula mobile robot according to claim 20 is the leg formula mobile robot according to claim 19, and said flat portion of a leg is being fixed to said floor-reaction-force detector.

[0045]

By doing in this way, further weight saving of a leg formula mobile robot's foot and simplification are attained.

[0046]

The leg formula mobile robot according to claim 21, Are the leg formula mobile robot according to claim 19 or 20, and said flat portion of a leg, Have said two or more grounding regions, and the center of said second joint, It has offset to a position from which distance to an apogee of two or more of said grounding regions serves as the minimum by plane view, and the center of said floor-reaction-force detector is established so that it may become close to a position from which distance to an apogee of two or more of said grounding regions serves as the minimum by

plane view rather than said second joint.
[0047]
In a leg formula walking robot given in the patent documents 1, the center of the second joint was offset to a grounding region by plane view, and the center of the second joint and the center of a floor-reaction-force detector were provided in the same position by plane view. In claim 21, since it brought close to a position which offsets the center of a floor-reaction-force detector to the center of the second joint by plane view and from which distance to an apogee of two or more grounding regions serves as the minimum, a value of floor reaction force detected can be made small, and a miniaturization of a floor-reaction-force detector is attained.
[0048]
The leg formula mobile robot according to claim 22, It is the leg formula mobile robot according to claim 19 or 20, said flat portion of a leg is provided with said two or more grounding regions, and said floor-reaction-force detector is formed in a position from which distance to an apogee of two or more of said grounding regions serves as the minimum by plane view.
[0049]
Thus, by setting up a position of a floor-reaction-force detector, a value of floor reaction force detected can be made small, and a miniaturization of a floor-reaction-force detector is attained. Since the maximum of floor reaction force inputted can be held down, a floor-reaction-force detector becomes difficult to break down. What is necessary is to just be provided in a position which a case of a floor-reaction-force detector described above, and a position of a case can be changed within limits located in a position which some cases described above. When it sees from a viewpoint of a miniaturization of a floor-reaction-force detector especially, it is desirable to provide the center of a floor-reaction-force detector in a position from which distance to an apogee of two or more of said grounding regions serves as the minimum by plane view.
[0050]
The leg formula mobile robot according to claim 23 is the leg formula mobile robot according to claim 20, and said floor-reaction-force detection means is characterized by being a distortion detection means to detect distortion of said flat spring part.
[0051]
What a "distortion detection means" is for detecting distortion of a flat spring part in this invention, for example, used a strain gage, a piezo-electric element, etc. is mentioned. A flat spring part bends in response to floor reaction force (distorted), and the distortion amount is correlated with floor reaction force. Therefore, floor reaction force is detectable by detecting distortion of a flat spring part.
Thus, it becomes possible by detecting distortion of a flat spring part to simplify composition of a foot further by having composition which detects floor reaction force.
It becomes possible by detecting distortion of a flat spring part to detect a state of a floor line.
[Effect of the Invention]
[0052]
According to this invention, the shock at the time of landing can be absorbed and a foot can provide a weight saving and the simplified leg formula mobile robot.
[Best Mode of Carrying Out the Invention]
[0053]
It explains taking for an example the case where the composition of the leg formula mobile robot of this invention is applied to the dipodia mobile robot in which autonomous movement is possible, and referring to drawings for the embodiment of this invention suitably hereafter. Identical codes are given to the same portion and the overlapping explanation is omitted. The expression about a position, a direction, etc. is explained on the basis of the state where the Y-axis was taken to the X-axis and a longitudinal direction, it took the Z-axis to the sliding direction at the dipodia mobile robot's cross direction, and the dipodia mobile robot took erect posture.
[0054]
<Dipodia mobile-robot R>
First, the dipodia mobile robot of this invention is explained with reference to drawing 1. Drawing

1 is a side view showing the dipodia mobile robot concerning this invention.
As shown in drawing 1, dipodia mobile-robot (only henceforth "robot") R, It is a robot which stands up, moves by the two legs R1 (one is illustrated) like human being (a walk, a run, etc.), has the upper body R2, the two arms R3 (one is illustrated), and the head R4, carries out autonomy and moves. And the back (back of the upper body R2) is equipped with the robot R in the form where the control device mount part R5 which controls operation of these legs R1, the upper body R2, the arm R3, and the head R4 is carried on the back.
[0055]
<Joint structure of the leg R1>
Then, the joint structure of the leg R1 of the robot R is explained with reference to drawing 2. Drawing 2 is a mimetic diagram showing the joint structure of the leg of drawing 1.
As shown in drawing 2, the robot R equips the leg R1 of each right and left with the six joints 11R (L) - 16R (L). The hip joints 11R and 11L (right-hand side is set to R and left-hand side is set to L.) for leg winding (circumference of the Z-axis) by which the joint of 12 right and left was provided in the crotch It is below the same. The hip joints 12R and 12L of the circumference of the roll axes (X-axis) of a crotch, It comprises the hip joints 13R and 13L of the circumference of the pitch axis (Y-axis) of a crotch, the knee joints 14R and 14L of the circumference of the pitch axis (Y-axis) of a knee region, the ankle joints 15R and 15L of the circumference of the pitch axis (Y-axis) of an ankle, and the ankle joints 16R and 16L of the circumference of the roll axes (X-axis) of an ankle. And the feet 17R and 17L are attached under the leg R1.
[0056]
That is, the leg R1 is provided with the hip joint 11R (L), 12R (L), 13R (L), the knee joint 14R (L) and the ankle joints 15R (L), and 16R (L). Hip joint 11R (L) -13R (L) and the knee joints 14R (L) are the thigh links 21R and 21L, and the knee joint 14R (L), the ankle joints 15R (L), and 16R (L) are connected by the leg links 22R and 22L.
The hip joint 11R (L) - 13R (L) are examples of the "first joint" in a claim, and the ankle joints 15R (L) and 16R (L) are examples of the "second joint" in a claim.
[0057]
The leg R1 is connected with the upper body R2 via the hip joint 11R (L) - 13R (L). It simplifies as the upper body link 23, and drawing 2 shows the connecting part of the leg R1 and the upper body R2. The tilt sensor 24 is installed in the upper body R2, and the inclination and angular velocity to the direction of the Z-axis (vertical axis) of the upper body R2 are detected on it. The rotary encoder (not shown) which detects the rotation is provided in the electric motor which drives each joint.
[0058]
It is the leg's R's1 being able to give a total of 12 flexibility about a leg on either side, and driving these 6*2=12 piece joints at a proper angle during a walk by such composition, The movement toward a request can be given to the whole leg (the leg R1 and foot 17), and he can be arbitrarily walked around three-dimensional space ("*" shows multiplication on these specifications).
[0059]
As shown in drawing 2, the publicly known 6 axial force sensors 52 are formed in the ankle joints 15R (L) and the lower part of 16R (L), The three direction component Fx of floor reaction force which acts on the robot R, Fy, Fz, and the three direction component Mx of a moment, My and Mz are detected from a floor line among the external force which acts on the robot R. The signal about floor reaction force, a moment, inclination, angular velocity, etc. which these 6 axial force sensor 52 and the tilt sensor 24 grade detected is told to the control unit 25 provided in the control device mount part R5, and is used for control of the posture of the robot R, operation, etc. The control unit 25 drives the joint which computed and described the joint drive control value above based on the data stored in the memory (not shown), and the inputted detecting signal.
[0060]
<The foot 17 of the robot R>
The foot 17R of the robot R (L) is attached to the end (floor line side) of the leg R1 via the ankle joints 15R (L) and 16R (L), and is provided with the 6 axial force sensor 52 and the foot member

61. Since the left leg (the left leg R1 and the foot 17L) and the right leg (the right leg R1 and the foot 17R) are symmetrical, when there is no necessity, R and L are removed and explained hereafter.
[0061]
<A first embodiment>
First, the foot 17 of the robot R concerning a first embodiment of this invention is explained with reference to drawing 3 thru/or drawing 5. Drawing 3 is a front view showing the foot of the dipodia mobile robot concerning a first embodiment of this invention. Drawing 4 is a side view showing the foot of the dipodia mobile robot concerning a first embodiment of this invention. Drawing 5 is a bottom view showing the foot of the dipodia mobile robot concerning a first embodiment of this invention. The leg R1 and the foot 17 of drawing 3 thru/or drawing 5 are shown as a state which removed suitably the armored part of the robot R shown in drawing 1. The left leg (the left leg R1 and the foot 17L) of the robot R is shown in drawing 3 thru/or drawing 5.
[0062]
Ankle-joints [of the << robot R] >>
Here, with reference to drawing 3 and drawing 4, the ankle joints 15 and 16 of the robot R are explained briefly. The ankle joints 15 and 16 of the robot R are constituted by connecting the spider 41 with the first pedestal section 51 of the leg link 22 and the foot 17.
The spider 41 is the member which combined with cross shape the axis 41a which makes a Y-axis a rotating shaft line, and the axis 41b which makes the X-axis a rotating shaft line. The both ends of the axis 41a are supported rotatable by the leg link 22. The both ends of the axis 41b are supported by the first pedestal section 51 rotatable. That is, the axis 41a is equivalent to the ankle joints 15, and the axis 41b is equivalent to the ankle joints 16.
[0063]
Behind [slanting] the leg link 22, the first rod 31 and the second rod 32 are formed. The first rod 31 is formed in the method of the diagonally rear to the right of the leg link 22, and is connected with the first pedestal section 51 via the spider 36. The second rod 32 is formed in the method of the diagonally rear to the left of the leg link 22, and is connected with the first pedestal section 51 via the spider 37. These first rods 31 and the second rod 32, It has composition which moves to a sliding direction, and moves the ankle joints 15 and 16, and is maintained to a predetermined angle by telling the driving force produced by rotation of the electric motor formed in the upper part (for example, the leg link 22, thigh link 21 grade) via reduction gears.
[0064]
For example, the first rod 31 and the second rod 32 are made to march out downward to float the tiptoe part of the foot 17, and the first rod 31 and the second rod 32 are degenerated upwards to float the heel part of the foot 17. The rod of a side to float is degenerated upwards and the rod of another side is made to march out downward to float either of the right and left of the foot 17. Operation of this first rod 31 and the second rod 32 is controlled by the above mentioned control unit 25.
[0065]
Foot 17>> of the << robot R
As shown in drawing 3 thru/or drawing 5, the foot 17 of the robot R is provided with the first pedestal section 51, the 6 axial force sensor 52, the second pedestal section 53, and the foot member 61 sequentially from the top (ankle-joints side).
[0066]
The first pedestal section 51 is the member provided in the upper part of the foot 17, and is a member connected with the ankle joints 15 and 16.
[0067]
The 6 axial force sensors 52 are devices which detect the moment of the floor-reaction-force advancing-side-by-side power of three directions, and the floor reaction force of three directions, as described above, and each part article is stored in the case (unitization). In this embodiment, the first pedestal section 51 and the 6 axial force sensors 52 are being fixed with

two or more bolts (not shown). The output of these 6 axial force sensors 52 is inputted into said control unit 25 via harness.
These 6 axial force sensors 52 are examples of the "floor-reaction-force detection means" in a claim, and it is also an example of a "floor-reaction-force detector."
[0068]
The second pedestal section 53 is the member provided between the lower part 52 of the 6 axial force sensor 52, i.e., 6 axial force sensors, and the foot member 61, and is a member for fixing the 6 axial force sensor 52 and the foot member 61 of each other. In this embodiment, the 6 axial force sensor 52 and the second pedestal section 53 are fixed with two or more bolts (not shown), and the second pedestal section 53 and the foot member 61 are being fixed with two or more bolts (not shown). Thus, since the 6 axial force sensor 52 and the foot member 61 were considered as the composition fixed via the second pedestal section 53, simplification of the structure of the foot 17 and a weight saving are attained. The structure with a group of each member of the foot 17 is not limited to the above mentioned thing.
[0069]
The foot member 61 is a member to which the second pedestal section 53 was attached caudad, and constitutes the main part of a floor line and the flat portion of a leg to ground. This foot member 61 is an example of the "flat portion of a leg" in a claim.
This foot member 61 is provided with the main part 62 of a flat spring, the first pars intermedia material 63, the first pair-of-shoes bottom material 64, the second pars intermedia material 65, and the second pair-of-shoes bottom material 66.
The main part 62 of a flat spring is a portion which supports prudence of the robot R, bending, and is mainly ** constituted with the base 62a and the spring part 62b extended from the base 62a. In this embodiment, the main part 62 of a flat spring is the member by which integral moulding was carried out to the shape by which the base end of the spring part 62b was connected with the base 62a.
The base 62a has flat plate shape, and has the shape which meets the bottom of the second pedestal section 53. The base end of the spring part 62b which carries out a postscript is connected with this base 62a, and the spring part 62b functions as a flat spring which used the joining segment with the base 62a as the base end.
The spring part 62b is an spring section extended downward at the angle theta (refer to drawing 4) from the end of the base 62a. According to this embodiment, there are four spring part $62b_1$, $62b_2$, $62b_3$, and $62b_4$, spring part $62b_1$ and $62b_2$ are extended ahead (toe direction) from the base 62a, and spring part $62b_3$ and $62b_4$ are extended from the base 62a to back (heel direction). As for these each spring part $62b_1$, $62b_2$, $62b_3$, and $62b_4$, it is desirable to consider it as identical shape, same intensity, and identitas performance (elastic modulus).
As for the angle theta, when the maximum floor reaction force Fz acts, it is desirable to set the base 62a as the minimum angle that is not grounded to a floor line. The maximum floor reaction force Fz here is reaction force which acts when the robot R runs at top speed and it grounds on one leg for example. This setting out can prevent the base's 62a grounding and having an adverse effect on the 6 axial force sensors 52, supporting prudence of the robot R according to the elastic force of the spring part 62b ($62b_1$-$62b_4$).
[0070]
This main part 62 of a flat spring should just be a raw material which can be functioned by the spring part 62b as a flat spring, for example, it may be formed from the metallic member (steel, an aluminum alloy, a Magnesium alloy, etc.). When formed from the combined members (fiber reinforced plastics etc.) especially strengthened with textiles, the weight saving of the main part 62 of a flat spring can be attained obtaining desired intensity and rigidity. Under the present circumstances, the intensity of the spring part 62b is securable by coinciding the grain direction of the textiles for strengthening with the direction (longitudinal direction) which goes to a tip part from the base end of the spring part 62b.
By changing the grain direction of each spring part 62b, anisotropy can be given and the spring

characteristics of each spring part 62b can also be changed.
As textiles for strengthening, carbon fiber, glass fiber, organic textiles, a metal fiber, etc. are preferred.
As for this main part 62 of a flat spring, it is desirable that it is the member by which integral moulding was carried out. By carrying out integral moulding of the main part 62 of a flat spring for which it has the composition with which two or more spring parts 62b (this embodiment four pieces) were attached to the one base 62a, reduction of the further part mark and simplification of the structure of a foot are attained.
[0071]
The first pars intermedia material 63 is the portion corresponding to the grounding region of the bottom of the spring part 62b, i.e., the damping member attached to the lower end part side (the same as that of the tip part side in this embodiment), and has the function to attenuate vibration of the spring part 62b produced at the time of grounding. This pars intermedia material 63 is also an example of the "attenuating means" in a claim. What should just have been formed from the raw material provided with the damping function, for example, was formed from foamed resin etc. is preferred for this first pars intermedia material 63. It may be the composition of installing the damper gear using fluid pressure, etc. as an attenuating means instead of the first pars intermedia material 63. The first pars intermedia material 63 and concomitant use are possible for this damper gear.
[0072]
The first pair-of-shoes bottom material 64 is a member attached to the bottom of the first pars intermedia material 63, and is a member which is located in the lower end part of the foot member 61, and is actually grounded to a floor line at the time of movement. This first pair-of-shoes bottom material 64 is a member which exhibits the function of a skid with the frictional resistance generated between floor lines. What should just have been formed from the raw material provided with the skid function, for example, was formed from rubber is preferred for this first pair-of-shoes bottom material 64. The bottom of this first pair-of-shoes bottom material 64 is the "grounding region" in a claim.
[0073]
The second pars intermedia material 65 is a damping member attached to the omitted portion of the bottom of the spring part 62b, and has the function to attenuate vibration of the spring part 62b produced when the second pair-of-shoes bottom material 66 which carries out a postscript grounds. What should just have been formed from the raw material provided with the damping function like the first pars intermedia material 63, for example, was formed from foamed resin etc. is preferred for this second pars intermedia material 65.
[0074]
The second pair-of-shoes bottom material 66 is a member attached to the bottom of the second pars intermedia material 65, and are the above mentioned first pair-of-shoes bottom material 64 and a member which exhibits the function of a skid similarly with the frictional resistance generated between floor lines. This second pair-of-shoes bottom material 66 is located up rather than the first pair-of-shoes bottom material 64.
[0075]
In this embodiment, the four flat spring parts S1, S2, S3, and S4 comprise the spring part 62b, respectively. In more detail, the flat spring part S1 comprises spring part $62b_1$, the flat spring part S2 comprises spring part $62b_2$, the flat spring part S3 comprises spring part $62b_3$, and flat spring part S4 comprises spring part $62b_4$. And when each flat spring part S1, S2, S3, and the first pair-of-shoes bottom material 64 provided at the tip of S4 ground, It has composition which supports prudence of the robot R, and the whole load according to the structure above the spring part 62b of the robot R in detail by each flat spring part S1 in the state where elastic deformation was carried out, S2, S3, and S4, these each flat spring part S1, S2, S3, and S4 carrying out elastic deformation. Therefore, though it is simple composition, prudence of the robot R can be supported, and the shock by floor reaction force can be absorbed further. It becomes possible by raising impact-absorbing ability to raise the move (walk, run) speed of the

robot R.
[0076]
A rubber bush etc. become unnecessary and the weight saving of the foot 17 becomes possible. Since the inertia force concerning the leg R1 becomes small by this weight saving, it becomes a structure suitable for high speed movement.
[0077]
Each flat spring part S1, S2, S3, S4, and the base 62a are arranged in the shape of a plane view abbreviation H character. Since the spring characteristics of each flat spring part S1 arranged so that two grounding regions may be arranged by this composition at front and each backside and it may be extended forward and backward, respectively, S2, S3, and S4 are suitable for the load control of the cross direction, This foot structure straddles by control of dipodia movement, and the grounding region of order, and is suitable for the control which moves the load center of the robot R to a cross direction. Since it is provided so that each class of the flat spring part S1, S2 and the flat spring part S3, and S4 may open a little toward a tip part, straddle is effective even if it is a case where the robot R inclined to right and left, and load shifts to a longitudinal direction.
[0078]
When floor line shape has unevenness, it is possible to be in the state (it has not grounded) where either each flat spring part S1 or - the S4 floated. In such a case, the flat spring part S1 - the bending spring characteristics (roll rigidity, pitch rigidity) of S4 will change nonlinearly. Therefore, the control unit 25 corrects a target foot positional attitude so that all the flat spring parts S1 - S4 may ground and bend based on the signal from the 6 axial force sensor 52, etc., and it is controlling it to take the posture in which the robot R generates target floor reaction force. The correction amount of this target foot positional attitude is computed by a nonlinear operation according to the float condition of the flat spring part guessed from the detection value of the 6 axial force sensor 52.
[0079]
Here, the foot 17 of the robot R is explained with reference to drawing 6 about the case where it is made to take down and ground just under. Drawing 6 is a mimetic diagram for which the example of the ground state of the foot of the dipodia mobile robot concerning a first embodiment is shown, and the important section extension mimetic diagram of (a) and (d of the figure in which (a) shows the early stages of grounding, the figure for which (b) shows the state where robot prudence was added, and (c)) are the important section extension mimetic diagrams of (b).
First, as shown in drawing 6 (a), each flat spring part S1, S2, S3, and the first pair-of-shoes bottom material 64 (grounding region) provided at the tip of S4 (only S4 is illustrated in S2) ground uniformly. If load is furthermore added to each flat spring part S1 - S4, floor reaction force will act on each spring part 62b, and the spring part 62b will bend. Under the present circumstances, the point P2 of the spring part 62b that the angle of the spring part 62b becomes theta' (theta'<theta), and serves as the grounding region upper part shifts outside to the point P1 of a grounding region (refer to drawing 6 (c) and (d)). That is, the flat spring part S2, the grounding point P1 by the side of the bottom of S4, and the distance between P1 spread from L (a) to L (b) (L (b) >L (a)). Since this gap will also become large if the angle theta is large here, it is desirable to set up the angle theta small in the range which was described above. Since the first pars intermedia material 63 also permits displacement of the direction of a floor line over the spring part 62b of the first pair-of-shoes bottom material 64, as shown in drawing 6 (b), it becomes possible to suppress the slide over the floor line of the grounding region accompanying bending of the spring part 62b. Therefore, it can suppress that the reaction force and the moment by this slide are inputted into the 6 axial force sensors 52, and become an obstacle of control of the posture of the robot R. The permissible dose and damping capacity of a slide can be suitably set up by changing the raw material and thickness of the first pars intermedia material 63.
[0080]
Here, with reference to drawing 5, the relation between position Pa from which the distance to

the apogee of a grounding region serves as the minimum, the center Pb of 6 axial force sensors, and the center Pc of ankle joints is explained.
In this embodiment, it is the center Pb (here) of 6 axial force sensors. it is in agreement with the Z shaft-orientations sensitivity center of the 6 axial force sensors 52. The distance to the apogee in plane view (drawing 5 bottom face view) is established above position (it is also called center of grounding region.) Pa (it is only hereafter indicated as "position Pa".) used as the minimum among the grounding regions established in the flat spring part S1 - bottom side of S4 in the standing-up state of rest of the robot R. According to this embodiment, each flat spring part S1, S2, S3, the distance L1 to the apogee of each grounding region of the bottom of S4, L2, L3, and L4 are equal.
According to this composition, the maximum of load which acts on the 6 axial force sensors 52 at the time of movement can be held down, and the miniaturization of the 6 axial force sensor 52 is possible. More exact measurement of floor reaction force and a moment is attained by having formed the 6 axial force sensor 52 in the foot 17, and having brought close to a grounding region.

[0081]
When the grounding region is arranged in the shape of a regular polygon, it will arrange so that the distance from each grounding region to the 6 axial force sensors 52 may become equal. It may be the composition using the floor-reaction-force detector which changes into the 6 axial force sensor 52, and detects the floor reaction force or the moment (for example, advancing-side-by-side power Fz of the floor reaction force of Z shaft orientations) of at least 1 axis.
[0082]
In this embodiment, the center Pc of ankle joints is offset to position Pa by plane view. Here, the intersection of the axis 41a and the axis 41b (refer to drawing 3) is equivalent to the center Pc of ankle joints. The center Pc of these ankle joints is established behind the robot R rather than position Pa. Thus, a postscript is carried out about the reason which the ankle joints 15 and 16 have offset back to the grounding region of the foot member 61.
The center Pc of ankle joints may be composition further offset also inside the grounding region of the foot member 61 (center side of the robot R). By offsetting the center Pc of ankle joints inside, interference of foot member 61 comrades of the adjoining feet 17R and 17L can be prevented, and a crawler bearing area can be secured, and the stability of the posture of the robot R can be maintained.
[0083]
In this embodiment, although the center Pb of 6 axial force sensors was established on position Pa, the center Pb of 6 axial force sensors should just be established so that it may become closer to position Pa than the center Pc of ankle joints by plane view at least. In other words, the center Pb of 6 axial force sensors should just be in the inside of the circle C which makes a radius length between position Pa and the center Pc of ankle joints a center [position Pa] by plane view. For example, it may be the composition that the center Pb of 6 axial force sensors is located on position Pa and the line segment which connects the center Pc of ankle joints. Even if it is this composition, the maximum of load which acts on the 6 axial force sensors 52 at the time of movement can be held down, and the miniaturization of the 6 axial force sensor 52 is possible. When the center Pb of 6 axial force sensors is on position Pa especially, the effect of the miniaturization of the 6 axial force sensor 52 can be demonstrated to the maximum.
[0084]
As shown in drawing 4, the flat spring part S1 - the lower end part (tip part) of S4 have the shape which curves toward a top as they separate from the ankle joints 15 and 16, and have the shape where the first pair-of-shoes bottom material 64 provided in the bottom is also the same. This is for making it possible to enlarge the time of grounding, and area which is kicked and is grounded at the time of a raising, and to secure the frictional force between floor lines, in order for control of a walk of this robot R to ground from a heel part and to have kicked by the tiptoe part. Since a grounding region is securable in a field, it leads also to stabilization of the posture of the robot R.
[0085]

Here, change of the flat spring part S1 at the time of the advancing movement (walk) of the robot R – the ground state of S4 is explained with reference to drawing 7. Drawing 7 is a mimetic diagram explaining change of the ground state of the flat portion of a leg at the time of the advancing movement (walk) of the dipodia mobile robot concerning a first embodiment.
First, when landing the foot member 61 which floated in the air, it is made to ground from the flat spring part S3 of a heel part, and the first pair-of-shoes bottom material 64 (grounding region) provided in S4 (drawing 7 (a)). And the whole grounding region of all the flat spring parts S1 – S4 grounds (drawing 7 (b)). And the flat spring part S3 of a heel part and the grounding region of S4 are floated, it grounds only in the flat spring part S1 of a tiptoe part, and the grounding region of S2, and the grounding region of all the flat spring parts S1 – S4 is floated by having kicked (drawing 7 (c)). By making this operation perform to the leg R1 on either side, the robot R carries out advancing movement. Thus, since the flat spring part S1 – the lower end part (tip part) of S4 have curved toward the top, even if the foot 17 becomes slanting to a floor line like [at the time of landing and a kick raising (drawing 7 (a)) (drawing 7 (c))], it becomes possible to secure a grounding region suitably. It is preferred to be set up so that the flat spring part 62b may curve toward a top as this curvature separates from the ankle joints 15 and 16 in the direction of movement of the robot R, and the curvature condition of the tip part of each flat spring part can be changed suitably. It may be the composition that at least one of the grounding regions has just curved, and all the grounding regions have curved.
[0086]
Then, the case where the robot R moves in a floor line with a level difference is explained. Drawing 8 is a mimetic diagram explaining the case where the dipodia mobile robot concerning a first embodiment moves in a floor line with a level difference.
As shown in drawing 8, in moving a place with a level difference to a floor line, there is a possibility that the portion in which the first pair-of-shoes bottom material 64 of the spring part 62b ($62b_2$ and $62b_4$ are illustrated) is not formed may ground. However, since the second pair-of-shoes bottom material 66 is formed in the omitted portion of the spring part 62b, the faults (generating of a slide, etc.) by the second pair-of-shoes bottom material 66 grounding, even if it is such a case, and the spring part 62b, i.e., a flat spring part, grounding directly are cancelable.
[0087]
Then, the reason which the ankle joints 15 and 16 have offset behind the grounding region of the foot member 61 is explained taking the case of the case where the robot R carries out high speed movement (run). Drawing 9 is a mimetic diagram explaining the case where the dipodia mobile robot concerning a first embodiment does high speed movement, and the figure with which ankle joints have offset (a) back to a flat portion of a leg, and (b) are figures with which ankle joints are located focusing on the cross direction of a flat portion of a leg. The numerals which added "'" are used for the same portion as drawing 9 (a) in drawing 9 (b).
As shown in drawing 9 (a), the ankle joints 15 and 16 are back offset to the foot member 61 (deflection). In this case, distance La from the ankle joints 15 and 16 to the front tip of the grounding part of the foot member 61 becomes long (La>La'). When the robot R carries out high speed movement (run), the knee joint 14 is bent deeply and the state where the floor reaction force F concentrates on the tiptoe part of the foot member 61 arises. At this time, the moment produced in the knee joint 14 serves as F*Lb. The moment produced in knee-joint 14' on the other hand when it is located in the ankle joints 15 and 16 focusing on the cross direction of foot member 61', as shown in drawing 9 (b) becomes F'*Lb'. Here, since it is Lb<Lb', F*Lb<F'*Lb' will be materialized if F=F'. In the case where the knee joint 14 is driven at the time of high speed movement (crookedness), this is materialized, when the direction of relative displacement (this embodiment front) and counter direction (this embodiment back) to the foot member 61 of the knee joint 14 are made to offset the ankle joints 15 and 16 to the foot member 61. And if the offset amount to the back to the foot member 61 of the ankle joints 15 and 16 is enlarged, it means that the burden placed on the knee joint 14 at the time of high speed movement can be suppressed more.
[0088]

<A second embodiment>
Then, the foot of the robot R concerning a second embodiment of this invention is explained focusing on a point of difference with a first embodiment.
Drawing 10 is a side view showing the foot of the dipodia mobile robot concerning a second embodiment of this invention. As shown in drawing 10, the foot 117 concerning a second embodiment was distorted instead of the 6 axial force sensor 52, and is provided with the detection means 152. And the first pedestal section 51 and the flat-spring means 61 are being fixed with two or more bolts (not shown).
The distortion detection means 152 are distortion of a flat spring part, and a thing which detects distortion of the spring part 62b in detail. Since the distortion of a flat spring part correlates with the floor reaction force inputted into a flat spring part, floor reaction force is detectable by detecting the distortion amount of a flat spring part. The detected distortion amount is told to the control unit 25 via harness, and is used for control of the posture of the robot R, movement, etc. As this distortion detection means 152, one or more strain gages or piezo-electric element attached to each spring part 62b is preferred.
As for the floor reaction force which this distortion detection means 152 detects, it is desirable that it is at least 1 axis (for example, floor reaction force Fz of Z shaft orientations), and they are six axes like the 6 axial force sensors 52 ****ed and described above.
[0089]
By forming the distortion detection means 152 in this way, it becomes possible to omit the floor-reaction-force detector 52, and the further weight saving of the foot 17 becomes possible. The shape of a floor line is detectable by detecting distortion of the flat spring part S1 - S4.
[0090]
<A third embodiment>
Then, the foot of the robot R concerning a third embodiment of this invention is explained focusing on a point of difference with a first embodiment.
Drawing 11 is a side view showing the foot of the dipodia mobile robot concerning a third embodiment of this invention. As shown in drawing 11, the foot 217 concerning a third embodiment is provided with the foot member 261 multilayered instead of the foot member 61.
[0091]
The foot member 261 is provided with two or more multilayered main parts 262,262 of a flat spring, and the viscous member 265 interposed between the main parts 262,262 of these flat springs. That is, the foot 217 comprises the spring part 262b, the viscous member 265, and the spring part 262b sequentially from a top, It has the multilayered flat spring parts S21-S24 (only S22 and S24 are illustrated), and has composition which can decrease vibration of the flat spring parts S21-S24 in the time of grounding, etc. by the interposed viscous member 265. The spring parts 262b and 262b multilayered among the multilayered main parts 262,262 of a flat spring are equivalent to "the multilayered flat spring" in a claim.
[0092]
The rubber etc. which were stuck on the main part 262 of a flat spring which this viscous member 265 should just be formed from the raw material which has a damping function, for example, adjoins are preferred.
In this composition, since it also has the function of the pars intermedia material 63 which the viscous member 265 described above, the pars intermedia material 63 is also omissible.
Here, although it had composition which multilayers the foot member 261 whole, the flat spring parts S21-S24 should just be multilayered at least.
[0093]
<A fourth embodiment>
Then, the foot of the robot R concerning a fourth embodiment of this invention is explained focusing on a point of difference with a first embodiment.
Drawing 12 is a bottom view showing the foot of the dipodia mobile robot concerning a fourth embodiment of this invention. As shown in drawing 12, the foot 317 concerning a fourth embodiment is provided with the connecting part 366,367 over which it was built, respectively between the flat spring part S1 and S2 and between S3 and S4.

It was built over the connecting part 366 between the flat spring part S1 and S2, it has connected both base end side and the base 62a, and has a function with which both the flat spring parts S1 and the action of S2 are synchronized. It was built over the connecting part 367 between the flat spring part S3 and S4, it reached both base end side, has connected the base 62a, and has a function with which the action of both the flat spring parts S3 and S4 is synchronized. Integral moulding of this connecting part 366,367 is carried out to the base 62a and the spring part 62b.
According to this composition, the rigidity of the roll directions of a flat spring part or a pitch direction can be adjusted. In not using this connecting part, roll rigidity becomes smaller than pitch rigidity. That is, what is necessary is just the composition which builds over a connecting part between two arbitrary flat spring parts to secure rigidity. A connecting part separates from the base 62a, and may be formed.
It may be not the connecting part by which integral moulding was carried out but the composition which builds over the connecting member of a different body between flat spring parts. As a connecting member, the rod form or long tabular member which has predetermined rigidity is preferred. The connection to a connecting member and each flat spring part may be based on fasteners, such as a pin.
[0094]
<The modification of a flat spring part>
Various examples of change can be considered about the shape of the flat spring part of this invention. Hereafter, the modification of the flat spring part of the leg formula mobile robot of this invention is explained. Drawing 13 and drawing 14 are the bottom views showing the modification of the flat spring part of the leg formula mobile robot of this invention.
[0095]
The flat spring part S1 of drawing 13 (a), S2, S3, and S4 are arranged in the shape of an abbreviated H character, as the first thru/or a fourth embodiment explained. Since it is provided so that the flat spring part S1, S2 and the flat spring S3, and S4 may open from the X-axis, respectively, the power which the robot R tends to reverse in the direction of a Y-axis (right and left) can also be opposed. The angle of this difference can be changed suitably. These flat spring parts serve as axial symmetry about the X-axis and a Y-axis, respectively, and, as for these four flat spring parts S1, S2, S3, and S4, it is desirable that they are the same spring coefficient, the same length, and identical shape. By doing in this way, the same spring characteristics as both advance and sternway can be demonstrated.
[0096]
The flat spring part S51 of drawing 13 (b), S52, and S53 are arranged in the shape of a Y character. Since the two flat spring parts S51 and S52 are provided ahead, it is fit for especially advancing movement.
[0097]
The flat spring part S54 of drawing 13 (c), S55, S56, and S57 are arranged in the shape of an H character. That is, the flat spring part S54, S56, the flat spring part S55, and the group of S56 are arranged on the same straight line extended forward and backward, respectively, and each class is parallel. These flat spring parts serve as axial symmetry about the X-axis and a Y-axis, respectively, and, as for these four flat spring parts S54, S55, S56, and S57, it is desirable that they are the same spring coefficient, the same length, and identical shape. By doing in this way, the same spring characteristics as both advance and sternway can be demonstrated.
[0098]
The flat spring part S58 of drawing 13 (d) and S59 are arranged in the shape of an I character. The shape of the main part of a flat spring is simple, and processing is easy.
[0099]
The flat spring part S60 and S61 are arranged further in the longitudinal direction what showed drawing 13 (a) the flat spring part S1 of drawing 14 (a), S2, S3, S4, S60, and S61, respectively. It has composition still stronger against the fall to a longitudinal direction by this flat spring part S60 and S61. When applying to a dipodia mobile robot, it may be the composition which equips only an outside direction with the flat spring part S60 or the flat spring part S61 to the leg R1 on

either side.

[0100]

The flat spring part S62 of drawing 14 (b), S63, S64, S65, and S66 are arranged so that the grounding region may serve as a vertex of a regular pentagon. For example, in order that the load center of gravity of a robot may remain in the quadrangle which consists of a grounding region of these four flat spring parts if the four remaining flat spring parts have grounded even if it is in the state in which the flat spring part of the piece floated, it has composition which is hard to reverse.

[0101]

The flat spring part S67 of drawing 14 (c), S68, S69, and S70 are arranged at cross shape. The composition shown in drawing 14 (b) and (c) is suitable for the robot which has 3 or more pairs of shoes, and does not have directional specificity.

[0102]

The flat spring part S71 of drawing 14 (d) and S72 are arranged before and behind the base 62a. The flat spring part S71 (S72) consists of the spring part 62b, and the plate 67 prolonged in the right-and-left (Y-axis) direction is attached to the tip part bottom of the spring part 62b. And the first pair-of-shoes bottom material 64 is attached to the both the right and left ends of the plate 67. By doing in this way, two or more grounding regions can be formed to one flat spring part.

[0103]

The flat spring part of these each shape can be combined with the composition of the above mentioned first thru/or a fourth embodiment, and may be a flat spring part of other shape.

[0104]

As mentioned above, although the embodiment of this invention was described, a design variation is possible for this invention suitably in the range which is not limited to said embodiment and does not deviate from the gist of this invention. For example, the robot R may be a leg formula mobile robot having the leg formula mobile robot or the three or more legs which were not limited to the dipodia mobile robot which illustrated, but were provided only with the one leg.
A leg formula mobile robot's move mode may not be limited to a walk, either, but and it may be movement by skipping etc. [skip and]
It is not limited to what also described above ankle joints and its driving mechanism.
The material of the upper thigh link 21, the leg link 22, the first pedestal section 51, and second pedestal section 53 grade can also be changed suitably, and these each member may consist of alloys (a titanium alloy, a Magnesium alloy, etc.) which have predetermined intensity, for example.

It is also possible to transpose to the vola member which united the first pair-of-shoes bottom material 64 and the second pair-of-shoes bottom material 66 with the pars intermedia material which unified the first pars intermedia material 63 and the second pars intermedia material 65, respectively.
Although it had composition which equips the bottom side of a flat spring part with various pars intermedia material and a vola member, when vibration of a flat spring part and the influence of a slide use it in a small floor line, it is also possible to omit pars intermedia material and a vola member.
It is also possible to be also able to change suitably the shape of the first pedestal section 51 and the second pedestal section 53, and it to make these the case of the 6 axial force sensors 52 and one. It may be the composition of also being able to change the shape of a base where a flat spring part is attached, and attaching a flat spring part to the case of the second pedestal section 53 or the 6 axial force sensors 52 directly. In this case, the second pedestal section 53 and the 6 axial force sensors 52 become with a base.
It is also possible to be also able to change the number of flat spring parts and shape suitably, and they to constitute one flat spring part combining two or more flat springs.
It may be composition provided with the flat spring part modification restricting part which prevents a flat spring part changing above a flat spring part in more than the specified quantity. As this flat spring part modification control means, it has a flange isolated and provided above a

flat spring part, and the projection provided in the bottom of this flange, for example, when a flat spring part carries out specified quantity modification, a flat spring part contacts a projection, and the composition which regulates modification beyond it is mentioned. By doing in this way, even if it is a case where excessive floor reaction force is inputted into a certain flat spring part, the deformation of a flat spring part can be regulated and breakage of a flat spring part can be prevented.
A design variation is possible also for the direction of the offset over position Pa of the center Pc of ankle joints, and distance suitably, and the center Pc of ankle joints may be located on position Pa.
[Brief Description of the Drawings]
[0105]
[Drawing 1]It is a side view showing the dipodia mobile robot concerning this invention.
[Drawing 2]It is a mimetic diagram showing the joint structure of the leg of drawing 1.
[Drawing 3]It is a front view showing the foot of the two-legged robot concerning a first embodiment.
[Drawing 4]It is a side view showing the foot of the two-legged robot concerning a first embodiment.
[Drawing 5]It is a bottom view showing the foot of the two-legged robot concerning a first embodiment.
[Drawing 6]It is a mimetic diagram explaining the example of the ground state of the foot of the two-legged robot concerning a first embodiment.
[Drawing 7]It is a mimetic diagram explaining change of the ground state of the flat portion of a leg at the time of the advancing movement (walk) of the two-legged robot concerning a first embodiment.
[Drawing 8]It is a mimetic diagram explaining the case where the two-legged robot concerning a first embodiment moves in a floor line with a level difference.
[Drawing 9]It is a mimetic diagram explaining the case where the dipodia mobile robot concerning a first embodiment does high speed movement.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[0105]
[Drawing 1]It is a side view showing the dipodia mobile robot concerning this invention.
[Drawing 2]It is a mimetic diagram showing the joint structure of the leg of drawing 1.
[Drawing 3]It is a front view showing the foot of the two-legged robot concerning a first embodiment.
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[Drawing 6]It is a mimetic diagram explaining the example of the ground state of the foot of the two-legged robot concerning a first embodiment.
[Drawing 7]It is a mimetic diagram explaining change of the ground state of the flat portion of a leg at the time of the advancing movement (walk) of the two-legged robot concerning a first embodiment.
[Drawing 8]It is a mimetic diagram explaining the case where the two-legged robot concerning a first embodiment moves in a floor line with a level difference.
[Drawing 9]It is a mimetic diagram explaining the case where the dipodia mobile robot concerning a first embodiment does high speed movement.
[Drawing 10]It is a side view explaining the foot of the dipodia mobile robot concerning a second embodiment.
[Drawing 11]It is a side view explaining the foot of the dipodia mobile robot concerning a third embodiment.
[Drawing 12]It is a bottom view explaining the foot of the dipodia mobile robot concerning a fourth embodiment.
[Drawing 13]It is a mimetic diagram explaining the modification of a leg formula mobile robot's flat spring part.
[Drawing 14]It is a mimetic diagram explaining the modification of a leg formula mobile robot's flat spring part.

[Translation done.]